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An annotated bibliography on

Seed Storage and Deterioration

A review of 20th century literature
reported in Foreign Languages

Agricultural Research Service
U. S. DEPARTMENT OF AGRICULTURE

AN ANNOTATED BIBLIOGRAPHY ON SEED STORAGE AND DETERIORATION

A Review of 20th Century Literature Reported in Foreign Languages

By Edwin James[1]

Preparation of this bibliography completes a compilation of literature on seed storage and deterioration taking place under various conditions and various lengths of storage period. Certain difficulties arose in its preparation that were encountered less frequently in the earlier part, which covers the literature published in the English language.[2]

Limited knowledge in regard to foreign publications led to the procurement and translation of several papers that are popular in nature or do not contain results of original experimental work. In order to assist the user of this bibliography in selecting original articles for further perusal, popular-type articles that are included are specified.

On several occasions it was found that certain authors published essentially the same experimental work in two languages. In these cases, an abstract of only one of the articles is given and attention is directed to other articles in which the same report appears.

Where abstracting publications have sufficed to provide the pertinent information of an article, they have been freely used as sources for the annotations. The source of information is identified, when applicable, either as from an abstract or from the English summary (or other summary of different language than the article proper). If the source is not specified, the annotation is from a direct translation. The English translations of the foreign titles follow, where possible, English versions given with abstracts or summaries.

The writer is indebted to various members of the faculty of Colorado State University for checking the accuracy of the German and French translations as made by him, and for the translation of articles appearing in Dutch, Spanish, and Italian. Special appreciation is extended to Miss Ruth O. Erickson of the Agricultural Research Service for the translation of several Russian articles for which no abstracts could be found.

For the sake of brevity the bulk of the experimental work for most articles is omitted; an abstract presents in general those conclusions that, in the opinion of the writer, contain the salient points of the article. Most of the articles reviewed contain valuable information not covered in the abstracts. The reader is referred to the original paper for further details.

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[2] James, E. An annotated bibliography on seed storage and deterioration. A review of 20th century literature reported in the English language. U.S. Dept. Agr., Agr. Res. Serv. ARS 34-15-1, 81 pp. 1961.

For the convenience of the reader a subject matter index follows the bibliography. An attempt is made to make this index more useful through the use of cross references. In many instances the information indexed is not found in the abstract but, rather, in the original.

1. ANONYMOUS. Om förvaring av frö. [The storage of seed.] Skogen 18: 14. 1931. [In Swedish.]

Norway spruce seed, which had a germinative energy of 98 percent in 8 days, had 86 to 90 percent after being stored unwinged in cloth bags for 5 years. Similar seed stored in airtight jars germinated 20 percent less than those in the bags. (From Biol. Abs. v. 5, No. 21160. 1931.)

2. AGRONOMOV, E. A., BUNDEL', A. A., GORYACHIKH, A. N., and KORENEV, N. A. [Data on the spontaneous heating of grains.] Bot. Zhur. SSSR (Jour. Bot. de l'URSS) 21: [196]-205. 1936. [In Russian. German summary, pp. 204-205.]

Self-heating of grain was attributed to the development of bacteria, and to penicillium fungus. Other species of fungi were destroyed by the heating of the grain. The catalase activity of the grain dropped in proportion to decreased germination. Acidity increased with temperature and the degree of injury. Natural sugars increased with self-heating. (From German summary.)

3. AHOLA, V. K. Männyn ja kuusen siemenen ilävyyden säilyminen. [The duration of germinability in pine and spruce seed.] Metsä-taloudellinen Aikakausl. 1951: 47-48. 1951. [In Finnish. English summary, p. 48.]

Seeds of pine and spruce with 85 to 95 percent germination kept their germinability for 10 to 15 years when sealed in bottles. (From English summary.)

4. AKI, S., and WATANABE, S. [Studies on the storage of Kintoki carrot. I. Influence of storage temperature and seed moisture on the germination of seeds.] Kagawa-ken Agr. Col. Tech. Bul. 7: 31-35. 1955. [In Japanese. English résumé, p. 35.]

This paper concerns the effect of initial short storage treatments on germination rather than storage per se. (From Hort. Abs. v. 27, No. 1511. 1957.)

5. BECKER, A. Zur Frage der Lagerung von gebeiztem Leguminosensaatgut. [The problem of storage of disinfected legume seeds.] Saatgut-Wirtsch. 10: 132-133. 1958.

Peas and beans, after treatment with various mercurial materials, were stored for a year without adverse effect. Seed treated with Cernox containing chinon-oxim-benzoyl-hydrazone had better germination than seed treated with Ceresan. (From Hort. Abs. v. 28, No. 3691. 1958.)

6. BECQUEREL, P. La longévité des graines macrobiotiques. [The long life of old seeds.] [Paris] Acad. des Sci. Compt. Rend. 199: 1662-1664. 1934.

Seeds of Cassia multijuga germinated after storage for 158 years in an herbarium; Cassia bicapsularis had a probable life of 199 years and Leucaena leucocephala* 155 years.

7. BLANC, A. Essais de conservation de blé en atmosphère confinée. [Studies on the preservation of wheat in a confined atmosphere.] Acad. d'Agr. de France Compt. Rend. v. 24, Suppl. of No. 18, 71 pp. 1938.

This publication considers airtight storage for the preservation of wheat for commercial purposes. Wheat stored for 13 months with 15 percent moisture had good baking properties.

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*Probably L. glauca.

8. BLANC, A. Les premiers résultats d'une nouvelle série d'essais de conservation de blé en atmosphère confinée. [The first results of a new series of studies on the preservation of wheat in a confined atmosphere.] Acad. d'Agr. de France Compt. Rend. 25: 1005-1015. 1939.

The quality of wheat in an open silo of 200-cwt. capacity was compared with that in sealed steel drums ranging in capacity from 100 to 600 cwt. Wheat with moisture contents from 10.5 to 14.7 percent in the drums was well preserved over a 9-month period. It was concluded that wheat with moisture contents up to 15.0 percent could be stored safely under hermetic conditions.

9. BLANCHARD, M. Conservation des semences de soja. [Conservation of seeds of soya.] Acad. d'Agr. de France Compt. Rend. 27: 500-503. 1941.

High viability was maintained in soybeans (*Glycine max*) of 10 percent moisture content by storing in a dry, ventilated area.

10. BRONCKERS, F. Recherches sur la conservation des semences de coton. [Research on the preservation of cottonseed.] Bul. Agr. du Congo Belge 49: [923]-933. 1958.

Seed reduced to 10 percent moisture had high germination after 6 months' storage.

11. BUSSARD, L. Contribution a l'étude des variations de la faculté germinative des semences au cours de leur conservation. [Contributions to the study of the variations in the germination of seed during their preservation.] Ann. Agron. [Paris] (n.s.) 5: [249]-277. 1935.

Seventy-six species of economic crops and 35 weed species harvested from 1891 to 1893 were stored in a laboratory and tested for germination over a period of years. Wheat, barley, and oats were maintained with high germination for 7, 7, and 9 years, respectively; rye for 3 years; and buckwheat for 9 years. The pasture grasses were, in general, shorter lived than the grains, the shortest lived being *Bromus erectus* and *B. inerme* and the longest *Holcus lanatus*. *Phalaris canariensis* had a usable longevity of 8 to 10 years, and *Panicum germanicum* (= *Setaria italica*) 7 to 9 years. In the forage legumes, *Melilotus alba* maintained 90 percent germination for 20 years. *Trifolium filiforme* deteriorated more rapidly than other legumes in the study. Among the large-seeded legumes, *Vicia faba* had 100 percent germination after 13 years. *Onobrychis sativa* (= *O. viciaefolia*) dropped from 91 to 35 percent in 8 years. The vegetable crops were shorter lived than the other groups, with acceptable germination at 3 years for asparagus, 2 for onion, 4 for carrot, 5 for lettuce, 3 for spinach, and 4 for celery.

12. BUSSE, I. Samenaufbewahrung im Vacuum. [Seed storage in vacuum.] Ztschr. f. Forst u. Jagdw. 67: 321-326. 1935.

Scotch pine seed germinating 92 percent was stored for 4 years under various degrees of vacuum at room temperature and in a cellar without loss of viability. The degree of vacuum had no effect on seed longevity. Stoppered bottles, also, were found to be satisfactory containers for storage in a cellar. Aspen seed, stored under 1 mm. of mercury for 5 years, lost only 15.2 percent of its germinating power at cellar temperatures, but the seed stored at room temperatures had only 2 percent germination. With a vacuum at 40 mm. of mercury, the aspen seed losses in germination after 4 years were: 10.9 percent for the seed stored in a cellar and 78.9 percent for that stored under room conditions. Without vacuum, aspen seeds were practically useless at the end of a year.

13. CARRA, P., and DESVERNES, P. Longévité des semences. [Longevity of seeds.] Rev. Hort. de l'Algérie 60: [17]-23. 1956.

A report on the longevity of seeds of various ornamental species. Storage procedures are not stated but appear to be under room conditions. Longevity varied from 3 to 4 years for *Melia azedarach* to less than 2 years for *Aristolochia elegans*, *Asparagus sprengeri*, *Iris foetidissima*, *Laurus nobilis*, *Paliurus spina-Christi* (= *P. aculeatus*), *Raphiolepis* spp., *Stapelia variegata*, *Tecoma stans*, and *Thunbergia coccinea*.

14. CHIRKOVSKIY, V. I. [How to safeguard germination of tobacco seeds in storage.] Tabak 13 (5): 43-[46]. 1952. [In Russian.]

Tobacco seed stored at 75 percent relative humidity and 18° C. dropped in germination from 90 to 82 percent in 18 months, whereas seed stored at the same relative humidity but at a 30° temperature lost viability in 7 months. In a ventilation experiment it was shown that seed moisture increases if the humidity of external air is higher than that of the storage area.

15. CHIRKOVSKIY, V. I. [The influence of aging of seeds on the development of tobacco plants.] Akad. Nauk SSSR Dok. 92: 439-442. 1953. [In Russian.]

Long storage of tobacco seed resulted in lower germination and yields of leaves per plant than were obtained by the use of fresh seed. Seed stored 5 years after a 5-day freezing treatment of -20° to -26° C. produced poorer seedlings than those stored without preliminary freezing. (From Hort. Abs. v. 24, No. 1658. 1954.)

16. CHIRKOVSKIY, V. I. [The development of tobacco plants in relation to the age of seeds and some other factors.] Krasnodar Vsesoyuzn. Nauch. Issled. Inst. Tabaka i Makhorki, Sborn. Nauch. Issled. Rabot No. 149, pp. 147-161. 1956. [In Russian.]

Aging of seeds of tobacco had a depressing effect on plant development, especially during early growth stages. Unfavorable storage conditions increased the depressing effect. (From Hort. Abs. v. 28, No. 2728. 1958.)

17. CHOPINET, R. La conservation des semences en atmosphère sèche; son intéret en sélection. [Seed storage in a dry atmosphere; its advantages in plant selection.] Internatl. Hort. Cong. Rpt., London (1952) 13: 1033-1043. [1953.] [In French. English summary, pp. 1042-1043.]

Samples of 18 seed lots were variously stored--in envelopes in a granary and in sealed tubes, some of which were under partial vacuum and some with $CaCl_2$. With seven exceptions, the seed stored in envelopes lost viability in 6 to 18 months. There was only a slight advantage in favor of partially evacuating the tubes, not enough to warrant such a procedure. *Salvia splendens* seed was the only lot that deteriorated seriously when sealed under vacuum or with $CaCl_2$.

18. CROCIONI, A. Durata del potere germinativo del seme di canapa in rapporto alle condizioni di conservazione. [Duration of viability of hemp seed in relation to storage conditions.] Bologna Univ. Cent. di Studi per le Ricerche sulla Lavoraz., Coltivaz. ed Econ. della Canapa, Quad. 9, 30 pp. [1950.]

Hemp seed varying in moisture from 8.6 to 15.1 percent was stored under seven combinations of temperature, humidity, and containers. The best results were obtained with seed of 8.6 percent moisture sealed in bottles and stored at 2° C.; under these conditions full viability was maintained for 40 months. Seed with 4.8 percent moisture under the same storage conditions lost only 4.5 percent in germination.

19. CROCIONI, A. La conservazione della germinabilità nel seme di canapa. [Preservation of germinating power in hemp seed.] Coltivatore e Gior. Vinic. Ital. 97: 51-53. 1951.

Article is an abbreviated form of the preceding reference, with the conclusion that degree of dryness of the seed is more important than low temperatures for the preservation of hemp.

20. D'AMATO, F. Mutazioni cromosomiche spontanee in plantule di Pisum sativum L. [Spontaneous chromosome aberrations in seedlings of Pisum sativum L.] Caryologia (1950-51) 3: [285]-293. 1951.

As compared with seedlings from fresh seed, pea seedlings from 4-year-old seed had reduced root tips that had lost meristematic activity. The maximum frequency of aberrations was found in roots 14 to 18 mm. long. Breakage of chromosomes appeared to be accomplished during the anaphase and telephase. (From Biol. Abs. v. 26, No. 2801. 1956.)

21. ECHEGARAY, D. M. Estudios hechos sobre temperaturas y humedades ambientes más convenientes para cereales y otras semillas en almacén. [Studies on the temperatures and humidities favorable for the preservation of cereals and other seeds in storage.] Econ. y Téc. Agr. [Spain] 4: 296. 1935.

A short, popular-type article calling attention to the importance of moderate temperatures and humidites for the preservation of seeds.

22. EIFRIG, H. Untersuchungen über Erhaltung der Keimfähigkeit von Beta-samen. [Investigations on the preservation of the germinability of beet seed.] Internatl. Seed Testing Assoc. Proc. 22: 269-275. 1957.

Seeds of sugar beet and mangels were stored in paper sacks and fabric bags in an attic subject to climatic variations. In 4 years, the germination of mangel seed stored in paper sacks dropped from 80 to 20 percent; seed stored in fabric bags dropped in germination from 75 to 13 percent. The beet seeds suffered only a slight loss in viability.

23. ESBO, H. Livskraftens bibehållande hos oskalat och skalat frö av timotej vid långtidslagring under ordinära betingelser på frömagasin. [Vitality of unhulled and hulled timothy seeds under ordinary storing conditions in whole bags.] K. Landtbr. Akad. Tidskr. 93: [123]-148. 1954. [In Swedish. English summary, pp. 146-148.]

Losses in germination of timothy in Sweden were largely confined to the summer seasons. Unhulled seed of the 1950 crop had no significant decline until the third summer. The mean reductions in germination of hulled seed amounted to 16 percent during the first year, but moisture contents from 14 to 17 percent had no effect on storability. Storing hulled seed for prolonged periods is discouraged. Differences in abnormalities were not found between hulled and unhulled seeds. Field emergence of unhulled seed ran 6 to 14 percent better than that of the hulled. (From English summary.)

24. ESDORN, I. Untersuchungen an Arnica montana L., die Lebensdauer ihres Saatgutes und ihre Anbaubedingungen. [Investigations on Arnica montana L., the longevity of its seed and its culture requirements.] Deut. Heilpflanze 1940 (18): 3-7. 1940.

With various methods used to preserve seed of arnica without temperature controls, the best results over a 2-year period were obtained with seed stored over quicklime, but storage in an unheated attic, in either cloth bags or corked bottles, was quite satisfactory.

25. FLORENCE, A. Graines maraichères, leur longévité et leur germination. [Seeds of the market gardener, their longevity and germination.] Rev. Hort. de l'Algérie 55: [117]-119. 1951.

A popular-type paper listing the probable longevities of 39 crop seeds, along with their temperature requirements for germination.

26. FLUITER, H. J. de. Waarnemingen betreffende het bewaren van zaadkoffie. [Observations concerning the storage of seed coffee.] Bergcultures 13: 1506-1512. 1939.

After preparing coffee seed for storage in the proportion of 3 kg. beans, 1 kg. charcoal, and 150 gm. water, the moisture content was stabilized at approximately 52 percent. As long as the moisture content remained above 28 percent, germination was satisfactory; between 27 and 25 percent germination dropped rapidly; and below 25 percent the seed lost all viability. The period of longest life was 22 months for seed stored at 92 to 98 percent relative humidity and 25° to 26° C.

27. FREDERIKSEN, P. S. Lagringsforsøg med spindhørfrø. [Investigations concerning the storage of flaxseed.] Lin 11: [1]-4. 1957. [In Danish. English summary, p. 4.]

Flaxseed with moisture contents of 8, 10, 12, 14, and 16 percent was stored in paper and jute sacks from December to April. No difference in containers was noted. A slight loss in germination occurred with moisture contents of 8 to 12 percent and a rapid loss with moisture above 12 percent. A relative humidity of 90 percent or above depressed germination even with storage temperatures near freezing. Temperatures of 10° to 12° C. were less harmful than the high humidities. (From Herb. Abs. v. 10, No. 1114. 1940.)

28. FULUTOWICZ, A., and BEJNAR, W. [The influence of the age of sugar beet seeds on their seeding value.] Rocz. Nauk Rolnicz. (Polish Agr. Ann.), Ser. A, 69: 323-340. 1954. [In Polish. English summary.]

No difference between 1- and 4-year-old sugar beet seeds was found with respect to the number of shoots per 100 seeds. Seeds between 5 and 7 years old showed a decline in germination. Age of seed up to 7 years had no effect on the value of beets produced. (From Biol. Abs. v. 30, No. 14577. 1956.)

29. GADD, I. Några försök rörande vattenhaltens betydelse vid lagring av varsäd i säckar. [The significance of water content in storing grain in sacks.] [Sweden] Statens Cent. Frökontrollanst. Meddel. 9: 58-69. 1934. [In Swedish. German summary, pp. 68-69.]

This paper reports short-term commercial storage of wheat and oats with moisture contents up to 18 to 20 percent. Moisture dropped gradually through the winter and early spring and rapidly during the summer. Moist grain dropped rapidly in germinability during the fall storage period. (From German summary.)

30. GADD, I. Ueber die Natur der Hartschaligkeit der kleinsamigen Leguminosen und den Einfluss der Lagerung auf dieselbe. [On the nature of hard seed coats in small-seeded legumes and the influence of storage on the same.] Internatl. Seed Testing Assoc. Proc. 10: [146]-174. 1938.

In the initial storage period, seeds with high moisture tended to become hard upon drying and remained harder than seeds hard initially with low moisture. Over a 2-year period the hard seed in commercial red clover dropped from approximately 25 to 1 percent when stored in an unheated warehouse. When seed was stored in a laboratory at 20° C. for 10 months, there was a slight initial increase in hard seed followed by a drop to near the original percentage.

31. GADD, I. Kvicksilverbetningens innerkan på lagringdugighten hos vårvete. [The influence of mercury-compound dressing on the storage capacity of spring wheat.] [Sweden] Statens Cent. Frökontrollanst. Meddel. 33: 31-59. 1958. [In Swedish. English summary, pp. 55-59.]

After treatment with mercurial compounds, wheat was stored in areas representing different climates in Sweden. The moisture content remained constant from autumn until summer, irrespective of the original content or storage locations. Germination remained unchanged in the controls and in seed treated with Panogen liquid, Betroxin T. D. dust (organic Hg plus TMTD), or with Hetoxin at double the recommended rate. Germination was injured with double the normal rate of Panogen, with most of the injury occurring in the first 2 months. (From English summary.)

32. GAWDA, J. Wpływ warunków przechowania na niektóre nasiona. [Influence of storage conditions on certain seeds.] Rocz. Nauk Rolnicz. i Leśnych (Polish Agr. and Forest Ann.) 43: [12]-17. 1937. [In Polish. German summary, pp. 15-17.]

Seeds of rye, oats, and buckwheat were maintained best over a period of 150 days when sealed with $CaCl_2$. Vetch seed became hard in the presence of $CaCl_2$. Moist seed, when sealed, quickly lost viability. The resistance of seeds to adverse conditions was, in decreasing order: Oats, buckwheat, and rye. (From German summary.)

33. GIOVANNOZZI-SERMANNI, G., and SCARASCIA-VENEZIAN, M. E. Ricerche analitiche in *Nicotiana rustica* con cromatografia su carta: modificazioni di alcune sostanze di riserva in semi di diversa età. [Paper-chromatographic analysis of *Nicotiana rustica*: variations in content of some reserve substances in seeds of different ages.] Tobacco [Rome] 60: 71-77. 1956. [English summary, pp. 76-77.]

With increasing age, amino acids were found to decline and sometimes to disappear. Others appeared as the result of protein hydrolysis. In dead seeds tryptophane, sucrose, and maltose were absent and valine was present. Iodine number and lipase activity were greater in old seeds. (From Hort. Abs. v. 26, No. 3876. 1956.)

34. GROSS, E. Veränderungen der Getreidesamen bei 10 jähriger Lagerung. [Changes in cereal seeds during 10 years' storage.] Ztschr. f. das Landw. Versuchsw. in Österr. 20: 471-487. 1917.

The work reported is covered in the abstract of the following reference.

35. GROSS, E. Veränderungen der Getreidesamen bei 10 jähriger Lagerung. [Changes in cereal seeds during 10 years' storage.] Biedermann's Zentbl. f. Agr. Chem. 48: 395-400. 1919.

Under room storage conditions, the germination of wheat dropped from 100 to 6 percent in 10 years; rye with an original germination of 99 percent lost all viability in 8 years; barley dropped from 100 to 6 percent in 10 years. Oats, however, dropped only to 79 percent from an original germination of 97 percent. The weights of the grains were relatively unchanged during the storage period, but there was a drop in moisture and an increase in dry weight.

36. GUILLAUMIN, A. Le vide comme moyen de prolonger la faculté germinative des graines. [The vacuum as a means of prolonging germinability in seeds.] [Paris] Acad. des Sci. Compt. Rend. 176: 1737-1739. 1923. (English title and short abstract in U.S. Dept. Agr. Off. Expt. Stas., Expt. Sta. Rec. 53: 520. 1925.)

The author concludes from a review of literature that the value of vacuum for preserving seeds is indefinite but recommends its use in the transportation of seeds difficult to ship.

37. GUILLAUMIN, A. Le maintien des graines dans un milieu privé d'oxygène comme moyen de prolonger leur faculté germinative. [Preservation of seeds in a medium free of oxygen as a means of prolonging their ability to germinate.] [Paris] Acad. des Sci. Compt. Rend. 187: 571-572. 1928.

Soybeans in open storage for almost 6 years lost viability. Final germination of those stored in an atmosphere free of oxygen was 92 percent and of those stored under vacuum, 100 percent.

38. GUSTAFSSON, A. Der Tod als ein nuklearer Prozess. [Death as a nuclear process.] Hereditas 23: 1-37. 1937. [In German. English summary, pp. 35-36.]

Sensitivity of seeds to small doses of X-rays increased gradually with the age of the seed, and aging was accelerated by high moisture content. Chromosome disturbances were more frequent in root tips, the cells of which were the first to divide. If life processes advanced to a certain stage but external conditions prevented their completion, the nuclei were found to degenerate and die. Aging of seed and loss of germination were associated with high moisture content.

39. HEINIS, F. Zur Kenntnis der Lebensdauer resp. Keimfähigkeit von Samen. [To the knowledge of longevity of the germinability of seed.] Geobot. Forsch. Inst. Rübel, Zürich, Ber. 1942: 75. 1943.

This reference is a short note regarding the longevity of seed of Blitum virgatum L. (Ambr.), which germinated after 35 years in an herbarium.

40. HEINRICH, M. Der Einfluss der Luftfeuchtigkeit, der Wärme und des Sauerstoffs der Luft auf lagerndes Saatgut. [The influence of atmosphere, moisture, temperature, and oxygen of the air on stored seed.] Landw. Vers. Sta. 81: [289]-376. 1913.

Twenty-four species of seed were subjected to four conditions of humidity at temperatures from 0° to 30° C. Seed high in moisture kept better when ventilated, but ventilation was not beneficial to seed previously dried. With air excluded, seed previously dried kept well at 30°. Temperatures below 5° were superior for storage.

41. HENNE, A. Der Kleindarre zum Abschied. [Prevention of drying out.] Schweiz. Ztschr. f. Forstw. 87: 82-90. 1936.

Spruce seed stored for 3 years in glass jars germinated as well and as quickly as fresh seed. Stored in paper sacks, the seed lost considerable viability in 3 years.

42. HOLTEN, A. Toaarig opbevaring af agern. [Storing acorns two years.] Dansk Skovfor. Tidsskr. 5: 191-194. 1920. [In Danish.]

A considerable quantity of acorns that had been laid down in the fall of 1918 gave a 40 percent germination in 1920. The author concludes that in order to preserve the acorns 2 years it is necessary to use Hauch's method* the first winter and the following spring to put the acorns down dry in a dry sand, and so deep that temperatures remain fairly constant. (From Jour. Forestry 19: 184. 1921.)

43. INSTITUT NATIONAL POUR L'ÉTUDE AGRONOMIQUE DU CONGO BELGE. La conservation des graines d'elaeis. [Storage of oil palm seeds.] Inst. Natl. . . . , Bul. d'Inform. I. N. E. A. C. 7: [31]-37. 1958.

Palm seeds were harvested in February, April, August, and November and stored 10 days and 1 1/2, 2 1/2, and 6 months. Germination percentage was unaffected by heat or storage up to 6 months. Speed of germination was inversely related to length of storage period. (From Hort. Abs. v. 28, No. 3097. 1958.)

44. ISACHENKO, B. L., ONCHUKOVA, M. M., PREDTECHENSKAYA, A. A., and LIPSKAYA, T. V. Über Selbsterhitzung des Korns. [Spontaneous heating of grain.] Acad. des Sci. de l'URSS Compt. Rend. (Dok.) (n.s.) 1: 507-509. 1934. [In Russian. German summary, p. 509.]

Heating of moist grain in the presence of oxygen was attributed to the development of micro-organisms. (From Chem. Abs. 28: 6485. 1934.)

45. JENSEN, C. Über die Möglichkeit, mit Hilfe von Lichtbehandlung, die Keimfähigkeit von Samen zu verlängern. [On the possibility of prolonging the viability of seeds by means of light treatment.] Ztschr. f. Bot. 37: [487]-499. 1942.

Cauliflower and cabbage seeds were exposed to the combined rays of a mercury-quartz and a Sollux (heat) lamp and stored with untreated checks. The irradiated seed of cauliflower lost only 7 to 8 percent in germination over a 7-year period as compared with 40 percent for the sealed check. Practically no loss in germination was incurred with treated cabbage seeds, whereas the untreated, sealed seed dropped 16 percent. The effect of irradiation was not due entirely to the destruction of micro-organisms.

46. JUEL, I. Der Auxingehalt in Samen verschieden Alters, sowie einige Untersuchungen betreffend die haltbarkeit der Auxins. [The auxin content of seeds of various ages, and some studies on the stability of auxin.] Planta 32: 227-233. 1941.

Auxins were found to be present in seeds after 26 to 38 years of storage. The loss of auxins did not seem to influence germinability.

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*A full account of this method of storing acorns occurs in Hauch, L. A. The cultivation of the oak (Quercus pedunculata) in Denmark. Quart. Jour. Forestry 17: 35-50, 88-97. 1923. A brief description of the method may be found in Toumey, J. W. Seeding and planting in the practice of forestry. Ed. 2, rev. and enl. by C. F. Korstian, 507 pp. New York. 1931.

The method follows: Acorns are first dried, but not overly so, by being spread 4 to 6 inches deep on a loft or barn floor and frequently turned with a shovel. They are brought to a dormant stage by being kept in a low 800-bu. storehouse with a 12-inch sod roof overlaid with a thick straw thatch. The roof also covers gables, which are fitted with doors. Ventilation is thus provided, but only to a small extent is the temperature allowed to depart from the freezing mark. The seeds are laid out in layers from time to time in the fall to build up the storage, perhaps to 12 inches for the winter. The desired moisture is maintained by frequent stirring and keeping the temperature uniform. To prevent damage to the acorns during below-freezing temperatures, the doors are covered with straw.

47. KONDŌ, M. Über die Dauer der Erhaltung der Keimkraft bei verschiedenen Samenarten in Japan. [Longevity of various seed species in Japan.] Õhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 3: [127]-133. 1926.

The length of life of 71 seed species in Japan was much shorter than that of similar seeds stored in Europe, Australia, or America. The short longevity was attributed to hot, damp summers.

48. KONDŌ, M. Über die Einwirkung des Kalks auf die Erhaltung der Keimkraft von Sämereien. [The influence of lime on preserving the viability of seeds.] Ōhara Inst. f. Landw. Forsch. [Kurashiki, Japan] Ber. 3: [135]-146. 1926.

Seeds of agricultural crops kept better when stored with lime and placed in sealed containers in a cool place. Work covered an 11-year period.

49. KONDŌ, M. Über die Erhaltung der Keimkraft von Sämereien und über Trocknungsmittel. [On the retention of germinating capacity of seeds and means of drying.] Ōhara Inst. f. Landw. Forsch. Ber. 3: [147]-151. 1926.

For drying rice, wood ash, straw ash, H_2SO_4, $CaCl_2$, and quicklime were used. $CaCl_2$ and quicklime were the best drying agents.

50. KONDO, M. [Storage of inadequately dried rice at low temperatures for five and a half years.] Ohara Agr. Inst. Rpt. 28: 1-47, 1936; 31: 232-237, 1939. 1936-39. [In Japanese.]

Allowable temperatures for rice stored 5 1/2 years in tin containers at particular moistures were: For 18 percent moisture, 0° to 5° C.; for 16 percent, below 5°; and for 14 percent, 10°. (From Biol. Abs. v. 23, No. 14584. 1949.)

51. KONDO, M., ISSHIKI, S., and TERASAKA, Y. [Storage of hulled rice with table-salt.] Ohara Agr. Inst. Rpt. 32: 78-94. 1941. [In Japanese.]

Table salt had no effect on the preservation of stored rice. (From Biol. Abs. v. 24, No. 6000. 1950.)

52. KONDO, M., and KASAHARA, Y. Some examples of the years' storage of seeds.] Crop Sci. Soc. Japan, Proc. 12: 21-24. 1940. [In Japanese. English title and summary, Jap. Jour. Bot. 11: (60). 1941.]

Seeds of several crops were stored over $CaCl_2$ for 10 years with resulting germination percentages of: 81.3 to 89.3 for Raphanus sativus; 73.0 for the average of two kinds of Cucumis sativus; 54.8 for Cucurbita pepo, 36.8 for Solanum melongena, 47.3 for Capsicum annuum, 74.8 for Zea mays, 88.5 for Avena sativa, and 61.5 (as one exceptional sample) for Oryza sativa from Italy. (From English summary.)

53. KONDO, M., and KASAHARA, Y. [A report on storage of seeds for 10 years with calcium chloride.] Ohara Agr. Inst. Rpt. 32: 304-310. 1941. [In Japanese.]

Rice, corn, radish, cucumber, eggplant, and other vegetable seeds ranged in germination from 35 to 85 percent after storage for 10 years over $CaCl_2$. (From Biol. Abs. v. 24, No. 10581. 1950.)

54. KONDO, M., and KASAHARA, Y. [Storage of seeds of forest trees. II. Seeds of the Japanese cedar *Cryptomeria japonica* and the Japanese cypress *Chamaecyparis obtusa*. III. Further studies on seed of *Cupuliferae*.] Ohara Agr. Inst. Rpt. 36: 497-536. 1944. [In Japanese.]

Perfect preservation of cedar and cypress seeds for 2 years was obtained with seed moistures of 4 to 8 percent, a relative humidity of 2 to 20 percent, and a temperature of 5° C. The best relative humidity for preservation of nongerminating live seeds of *Cupuliferae* was found to be 80 percent. (From Biol. Abs. v. 24, No. 4974. 1950.)

55. KONDÔ, M., MATSUSHIMA, S., and OKAMURA, T. Keimkraft, Nährstoffe und B-Vitamin der im kohlensäuren- und luftdichten Verschlusse 4 Jahre lang aufbewahrten Reiskörner. [Germinability, food value, and Vitamin B content of rice kept 4 years in vessels impervious to CO_2 and air.] Imp. Acad. Japan, Proc. 5: 159-160. 1929. [In German.]

After 4 years, rice sealed with CO_2 or air germinated 97 to 99 percent, but rice stored in straw bags lost all viability in this period. The sealed rice showed no differences in composition as compared with fresh rice. (From Biol. Abs. v. 4, No. 929. 1930.)

56. KONDO, M., and MIZUTA, T. [An experiment on storage of hulled rice in paper bags.] Ohara Agr. Inst. Rpt. 36: 537-546. 1944. [In Japanese.]

Rice stored in single-fold kraft paper bags absorbed moisture over a 1-year period, with an accompanying slight decrease in viability. (From Biol. Abs. v. 23, No. 14585. 1949.)

57. KONDO, M., NAKASAWA, T., and HONJO, M. [The effect of moisture content and temperature upon the quality of stored wheat. I, II, III, and IV.] Ohara Agr. Inst. Rpt. 31: 35-70, 1939; 32: 156-215, 1941. 1939-41. [In Japanese.]

I. In sealed containers the permissible moisture contents of wheat for 6 months' storage were: 13.5 percent for a temperature below 25° C., 15.3 for one below 20°, and 17.0 for one below 10°. II. For 1 year's storage, the permissible moistures were 13.5 percent for below 20°, 15.3 for below 15°, and 17.0 for below 10°. III and IV. It appeared that wheat with 13.0 percent moisture could be safely stored at 15° for 3 years, at 20° for 2 years, and at 25° for 1 year. Wheat with 15 percent moisture was satisfactorily stored at 10° for 3 years, at 10° to 15° for 2 years, and at 15° to 20° for 1 year. (From Biol. Abs. v. 23, No. 14586. 1949.)

58. KONDO, M., and OKA, H. [Storage of wheat in moisture-proof paper bags. I, II, III. With supplementary notes on rice storage.] Ohara Agr. Inst. Rpt. 31: 71-88, 1939; 32: 146-155, 1941; 35: 39-54, 1943. 1939-43. [In Japanese.]

I. Triple-kraft and single-asphalted paper were used in a 16-month storage study of wheat. Gain in moisture of wheat was 0.7 to 1.5 percent. II. The bags were able to exclude moisture for 1 year but not for 2 years. III. Over a 3-year period, the bags were almost equal to cans as far as moisture, germinability, and quality of seed were concerned. (From Biol. Abs. v. 23, No. 18249. 1949.)

59. KONDO, M., and OKA, H. [Influence of moisture content and temperature upon quality of stored wheat. V.] Ohara Agr. Inst. Rpt. 35: 65-82. 1943. [In Japanese.]

Wheat was stored safely for 3 years below 25° C. with 10 percent moisture, below 20° with 12 percent, and below 10° with 14 percent. (From Biol. Abs. v. 23, No. 26008. 1949.)

60. KONDÔ, M., and OKAMURA, T. Einwirkung des kohlensäure- und luftdichten Verschlusses auf die Reiskörner während der Aufbewahrungszeit. [Effect of CO_2 and airtight containers on rice during storage.] Imp. Acad. Japan, Proc. 3: 706-709. 1927. [In German.]

Rice stored in airtight containers in either air or CO_2 was perfectly preserved for 3 years, with CO_2 storage having a slight advantage. The same work is reported in English in Ōhara Inst. f. Landw. Forsch. Ber. 4: [1]-18. 1929. (From Biol. Abs. v. 2, No. 11783. 1928, and the English version.)

61. KONDO, M., TAKAHASHI, R., and TERASAKA, Y. [Storage of seeds of forest trees. I. Seed of Cupuliferae.] Ohara Agr. Inst. Rpt. 32: 283-303. 1941. [In Japanese.]

Of the various temperatures tried for preserving cupuliferous seeds over a 2-year period, 0° to 5° C. appeared to be best. (From Biol. Abs. v. 24, No. 7258. 1950.)

62. KONDO, M., TAKAHASHI, R., TERASAKA, Y., and KAIHARA, H. [Storage of rice in concrete silos. III. Storage of insufficiently dried rice for over 4 years after desiccation by heating. IV. Storage for 7 years.] Ohara Agr. Inst. Rpt. 32: 95-113, 1941; 36: 198-208, 1944. 1941-44. [In Japanese.]

III. Rice with 15 percent moisture lost all viability when dried to 13 percent followed by storage in a 50-bushel silo for 4 years. IV. Careless treatment in the 7-year experiment led to the deterioration of the rice. (From Biol. Abs. v. 23, No. 20768. 1949.)

63. KONDO, M., and TERASAKA, Y. [Experiments on storage of rice at low temperature.] Ohara Agr. Inst. [Kurashiki, Japan] Rpt. 31: 232-237, 1939; 33: 197-207, 1942. 1939-42. [In Japanese.]

Rice with 14 percent moisture, sealed in glass containers and stored at 10° C., maintained perfect quality and 90 percent germination for 8 years. With a moisture content of 17 percent and higher, germination was lost. (From Biol. Abs. v. 23, No. 28680. 1949.)

64. KRETOVICH, V. L. [Physiologico-biochemical bases for the storage of [wheat] grain.] [136] pp. Moscow-Leningrad. 1945. (Published by Akad. Nauk SSSR, Inst. Biokhim.) [In Russian. English trans. by K. S. Chester; in Libr., USDA: 215 numb. leaves. [n.p.] [1946?].]

Drying grain decreases the reduction-oxidation activity of the enzymes, the amylolytic activity, and the content of physiologically unstable substances. In grain below 16 percent moisture, much of the CO_2 is produced anaerobically; thus, the oxidation-reduction processes in stored grain are conditioned by moisture rather than laws governing aerobic respiration. Critical moisture content for the storage of grain is 14.5 to 15.0 percent. (From Chem. Abs. 40: 1237. 1946.)

65. KRETOVICH, V. L., and USHAKOVA, E. N. [KRETOWITCH, W. L., and USCHAKOWA, E. N.] Über die kritische Feuchtigkeit und den Atmungsgaswechsel des Kornes beim Aufbewahren. [On the critical moisture content and respiration gas exchange of grain in storage.] Acad. des Sci. de l'URSS Compt. Rend. (Dok.) (n.s.) 29: 115-119. 1940. [In German.]

At 25° C. the critical humidity for stored wheat and rye was found, from the respiration quotient, to be 15.5 percent. With a low humidity, a large part of the CO_2 evolved was due to anaerobic activity. Only beyond the critical humidity does the respiration quotient approach a unit value. Respiration of germinated seeds was higher than ungerminated seeds at the same humidity.

66. KRETOVICH, V. L., and USHAKOVA, E. N. Über kritische Feuchtigkeit und Gaswechsel des Kornem bei Lagerung. [On the critical moisture content and gas exchange of grain in storage.] Akad. Nauk SSSR Dok. 29: 118-121. 1940.

Reference carries the same information abstracted in the previous reference.

67. KREYGER, J. Het drogen en bewaren van granen en zaden. [The drying and storage of grain and seed.] Cent. Organ. T. N. O. Alg. Tech. Afd. Rap. T. A. 239, 94 pp. 1948. [Processed.]

The papers of 83 workers are reviewed, and are largely confined to the drying of grain and seeds. No original research work is involved. Many tables relating to the effect of moisture and temperature on the keeping qualities of seeds have been extracted from the papers reviewed.

68. KREYGER, J. Het bepalen van de damp-druckisothermen van een 9-tal zaadsorten. [The determination of vapor-pressure isotherms in the seeds of 9 crops.] [Wageningen] Cent. Inst. v. Landbouwk. Onderzoek., Droogtechn. Lab., Pub. 39, 7 pp. [1954.]

Information in the article is essentially covered in the following reference. (From Field Crops Abs. v. 8, No. 1082. 1955.)

69. KREYGER, J. Het drogen en bewaren van zaaizaden. [Drying and storage of seed.] Zaadbelangen 8: 6-7, 21-23. 1954. [In Dutch.]

Moisture equilibria for humidities from 10 to 95 percent are given. At 70 percent relative humidity and 20° C. the equilibria were as follows: Rape 8.0, sugar beet 13.3, perennial ryegrass 14.3, rye 15.1, maize 14.6, oats 14.0, wheat 15.0, peas 14.8, and beans 13.4 percent. An equilibrium with a relative humidity of 70 to 75 percent is recommended before storage. When seeds were stored at 2°, 12°, 18°, and 25° the higher temperatures were deleterious when the humidities were high. Seeds of maize, perennial ryegrass, sugar beet, and rye were damaged when stored at 12° with 75 to 80 percent relative humidity.

70. KREYGER, J. Resultaten van een bewaaronderzoek onder afsluiting van de lucht met een negental landbouwzaaizaden. [Results from airtight storage tests with the seeds of 9 crops.] [Wageningen] Cent. Inst. v. Landbouwk. Onderzoek., Droogtechn. Lab., Pub. 67, 13 pp. [1956.] [In Dutch. English summary.]

The safe moisture contents for the storage of seeds of rape, perennial ryegrass, sugar beet, rye, oats, maize, lupine, peas, and broad bean varied according to the seeds from 12 percent at 2° C., 9 to 17 percent at 12°, 8 to 16 percent at 18°, and 6 to 13 percent at 25°. (From Field Crops Abs. v. 10, No. 324. 1957.)

71. KRSTIĆ, M. Contribution à l'étude de la conservation des graines de l'Orme champêtre (Ulmus campestris).* [Contribution to the study of the preservation of seed of the plains elm (Ulmus campestris).] Inst. za. Nauch. Istrazh. u Šumarst. Srbije, Rad. (Inst. de Rech. Forest. de Serbie, Ann.) 1: 53-61. 1950. [In Serbo-Croatian. French résumé, pp. 60-61; French title in table of contents.]

As a result of 16 different tests on the preservation of elm seeds, it was found that those over $CaCl_2$ in a desiccator in a heated room, and those lightly coated with paraffin stored in an unheated room, could be maintained for 6 months with approximately 30 percent of their initial germination. (From French résumé.)

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*Ulmus campestris Mill is not used by modern authors; the equivalent is probably U. procera Salisb.

72. KÜHL, H. Die Haltbarmachung des Brotgetreides. [The preservation of bread grains.] Landw. Vers. Sta. 117: [217]-228. 1933.

Drying bread grains in layers until a moisture reduction is reached that will prevent the activity and development of molds and bacteria is recommended.

73. KÜHL, H. Im Kampf gegen die durch das Wachstum von Schimmelpilzen und Bakterien bedingten Wertverminderungen von Brotgetreide und Mehl. [Combatting the deterioration of grains and flour used for bread caused by the growth of fungus mold and bacteria.] Mehl u. Brot 40: 505-506. 1940.

This paper calls attention to the conditions influencing the development of micro-organisms and the importance of storing grain at 14 to 15 percent moisture.

74. KUZNETSOV, P. G. [Storing acorns.] Lesnoe Khoz. 6 (2): 57-58. 1953. [In Russian.]

At the Tikhorets Leskhoz acorns were preserved best by a storage method involving alternate layers of snow 10 to 15 cm. thick and acorns 5 to 8 cm. thick, to produce a mound 1.5 m. high. This mound is capped with packed snow and ice and a final covering of 1 m. of straw or similar material.

75. LAMBERT, A. La conservation du blé à l'air libre par le procédé des cellules métalliques. [The preservation of wheat in the open air by means of metal cells.] Génie Rural 44: 378-379. 1951.

This paper describes the use of open metal silos for storing wheat and has no experimental data.

76. LITYŃSKI, M. [The influence of moisture in the environment on the vitality of certain species of vegetable seeds.] Rocz. Nauk Rolnicz. (Polish Agr. Ann.), Ser. A, 76: 217-294. 1957. [In Russian. English summary.]

Ten species of vegetable seeds were stored 2 years in humidities from 40 to 90 percent. Humidities between 40 and 60 percent were satisfactory for all seeds. Seeds of peas, beans, and tomatoes tolerated 75-percent relative humidity. Optimum and permissible humidity limits for storage are given. (From Hort. Abs. v. 28, No. 1383. 1958.)

77. LOEBEL, M. Ein kleiner Aufbewahrungsversuch mit Nadelholzsamen in Humus. [A small storage study with pine seed in humus.] Forstwiss. Centbl. 84: [237]-242. 1940.

Seeds of spruce, pine, and larch were stored with and without humus for 12 years. Germinations of pine and larch seeds were not influenced by the storage media. In later tests, spruce seeds stored in humus germinated better than those without humus. Germinations in all tests were low after 8 years and insignificant after 10 years.

78. LOWIG, E. Beiträge zur Frage der Saatgutlagerung. [Contributions to the problem of seed storage.] Saatgut-Wirtsch. 5: 148-150. 1953.

Five varieties of _Viola_ _tricolor_ were stored for 13 months in a heated room in sacks, also in metal boxes containing quicklime. Differences in germination between these methods favored the latter by 10 to 32 percent; moisture contents were about 2 percent lower.

79. LOWIG, E. Beiträge zur Frage der Saatgutlagerung. (2. Mitteilung). [Contributions to the problem of seed storage. (Report No. 2).] Saatgut-Wirtsch. 6: 124-127. 1954.

In addition to a report on the storage of Viola over quicklime, a report is given on the moisture uptakes by Viola and tomato seeds over a 12-day period with the use of various packaging materials. There were no significant differences between parchment, waxed paper, or cellophane bags, and no significant differences between seeds. In a 6-month period, beans with 10.84 and 16.08 percent initial moisture contents were stored under various humidities. The beans adjusted their moisture contents to their respective humidities regardless of their initial percentages.

80. LOWIG, E. Beiträge zur Frage der Saatgutlagerung. (3. Mitteilung). [Contributions to the problem of seed storage. (Report No. 3).] Saatgut-Wirtsch. 7: 14-16. 1955.

Eleven vegetable crop seeds, unpackaged in wooden boxes and in paper sacks, were stored under room conditions and compared with respect to rate of deterioration. Over a period of 22 months, the rate of decline was always greater with paper-bag storage. The decline in head lettuce seed was most pronounced, with complete loss of viability after 1 year of storage in paper bags. Storage conditions were 17° to 21° C. and approximately 45 percent relative humidity.

81. LOWIG, E. Saatgut-Lagerschäden an Salat-Keimpflanzen. [Storage injury in lettuce seed.] Saatgut-Wirtsch. 10: 160-162. 1958.

Under storage conditions not stated, lettuce seed in 10-gm. bags suffered a severe decline in germination and developed abnormalities, whereas the seed stored in 10-kg. bags kept well.

82. MASUMOTO, S. Über den Einfluss der Erhitzung während der Aufbewahrung auf die Keimung des Tabaksamens. [On the influence of heating during storage on the germination of tobacco seed.] Hiroshima Univ. Jour. Sci., Ser. B, Div. 2 (Bot.), 3: [165]-[190]. 1939. [In German.]

This paper covers technique of germinating tobacco seed rather than its storage. However, it was found that heating seed to 70° C. accelerated the germination of the seed, also that heating to 80° for 5 days decreased the capacity of the seed to germinate fast but did not affect its germination power.

83. MERCIER DES ROCHETTES, A. La conservation des blés à l'air libre. [The preservation of wheat in the open air.] Jour. d'Agr. Prat. 65: 509-512. 1936.

Covers the construction of storage chambers and buildings for the storage of wheat, but no experimental data on storage are involved.

84. MÖLLER, K. Lágring av spannmål. Nyare erfarenheter och metoder. [The storage of grain. Newer experiences and methods.] K. Landtbr. Akad. Handl. och Tidskr. 75: [353]-370. 1936. [In Swedish.]

Translated only to the extent of finding it is a review of work by other authors and contains no experimental data.

85. NAKAJIMA, Y. Untersuchungen über die Keimfähigkeitsdauer der Samen. [Investigations on duration of germinability of seeds.] Bot. Mag. [Tokyo] 41: 604-632. 1927. [In Japanese. German summary, pp. 630-631.]

Seed stored in a closed flask with $CaCl_2$ retained good viability for 9 years. Seeds of *Hordeum*, *Triticum*, *Panicum crusgalli* var. *frumentacea* (= *Echinochloa crusgalli* var. *frumentacea*), *Zea*, *Brassica campestris*, *Betuea japonica* var. *tauschii* (= *B. platyphylla* var. *japonica*) were uninjured by the desiccants, whereas germination of *Oryza sativa*, *Phaseolus radiatus* var. *pendulus*, *Vicia sativa*, *Setaria italica*, *Cryptomeria japonica*, *Chamaecyparis obtusa*, and *C. pisifera* was reduced. Quicklime as a desiccant proved to be occasionally injurious. The water-absorbing capacity of various desiccating materials tested was, in the following decreasing order: Phosphoric acid, concentrated H_2SO_4, quicklime, fused $CaCl_2$, and anhydrous $CaCl_2$. (From German summary.)

86. NAKAMURA, S. [Storage of vegetable seeds.] Hort. Assoc. Japan. Jour. 27: 32-44. 1958. [In Japanese. English summary, p. 32.]

Seeds of turnip, Chinese cabbage, mustard, cucumber, watermelon, squash, tomato, and radish were long lived. Seeds of carrot, edible burdock, Welch onion, onion, spinach, cabbage, lettuce, pea, and bean were shorter lived. Cold storage was less effective in preserving viability than room temperatures with a dry atmosphere. Longevity was associated with heat resistance.

87. NAVASHIN [NAWASCHIN], M. Altern der Samen als Ursache von Chromosomenmutationen. [Aging of seeds as cause of chromosome mutations.] Planta 20: [233]-243. 1933.

In 170 individual roots of *Crepis tectorum* from seeds 7 to 8 years old, 29 percent showed mutations, mostly of the translocation type. These were observable in poor root development, chimeras in root structure, triploids, and extra chromosomes in single cells.

88. NAVASHIN, M. S. [Aging of the embryo as a cause of mutations.] Sovet. Bot. No. 6, pp. 27-44. 1934. [In Russian.]

No translation of this article was attempted owing to the similarity of the title to the preceding one. On the basis of other articles by the above author, it appears that this one is a Russian version of the preceding reference.

89. NAVASHIN, M. S., and GERASIMOVA, H. N. [Ye. N.] [Changes in species properties in the case of storage of seeds.] Semenovodstvo* 1935 (1): [36]-46. 1935. [In Russian.]

Article only partially translated for this annotation. Tables indicate a general lowering of viability with age of *Crepis* seeds. In the progeny from old seeds, productivity ranged from full fertility to complete sterility. In one family studied, complete fertility was 3 times as high as in another, but in related families the reverse prevailed to the extent that one family with lowest fertility had almost 4 times as many steriles as another with high fertility. Progeny of different families showed differences in mutation rates but no definite correlation was observed between age of seed and mutation rates.

90. NAVASHIN, M. S., and GERASIMOVA, H. N. [GERASCHMOVA, YE. N.] [Nature and causes of mutations. I. On the nature and importance of chromosomal mutations taking place in resting plant-embryos due to their aging.] Biol. Zhur. [Moscow] 4: 593-[634]. 1935. [In Russian. English summary, pp. 627-629.]

Article was not translated. Refer to the following reference for essentially the same title.

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* Later in 1935 becoming Selektsiya i Semenovodstvo.

91. NAVASHIN [NAWASCHIN], M., and GERASIMOVA [GERASSIMOWA], H. Natur und Ursachen der Mutationen. I. Das Verhalten und die Zytologie der Pflanzen, die aus infolge Alterns mutierten Keimen stammen. [Nature and cause of mutation. I. The behaviour and cytology of plants arising as a result of aging of mutant embryos.] Cytologia [Tokyo] 7: 324-362. 1936.

In work with Crepis spp. and rye it was found that chromosome aberrations increased with the age of the seeds, with mutation rates reaching 40 to 50 percent in the case of 7- to 8-year-old seeds. Translocations, fragmentations, and inversions were observed. Of 162 aberrations found, 150 were translocations and 12 inversions.

92. NAVASHIN [NAWASCHIN], M., and GERASIMOVA [GERASSIMOWA], H. Natur und Ursachen der Mutationen. III. Über die Chromosomenmutationen, die in den Zellen von ruhenden Pflanzenkeimen bei deren Altern auftreten. [Nature and causes of mutation. III. On the chromosome mutations which appear in the cells of resting plant embryos on their aging.] Cytologia [Tokyo] 7: 437-465. 1936.

Paper consists of a review of literature. Attention is called to the importance of mutations in agricultural practice.

93. NIESER, O. Saatlagerung. [Seed Storage.] Saatgut-Wirtsch. 7: 42-43. 1955.

In 6-month storage of lettuce seed under room conditions, no difference was found in the germination of seed stored in paper sacks as compared with that stored in glass bottles. Temperatures ranged from 18° to 23° C. and humidities from 52 to 83 percent.

94. NOVIKOV, G. N., and NIKOLAEVA, M. G. [Preserving viability in seeds of Kochia prostrata.] Bot. Zhur. SSSR (Jour. Bot. de l'URSS) 36: 69-72. 1951. [In Russian.]

Good results were obtained by storing seed of Kochia prostrata over $CaCl_2$ with aeration. Hermetic sealing was deleterious. The best temperatures found for preservation were between 1° and 10° C. (From Herb. Abs. v. 21, No. 838. 1951.)

95. OEHLER, E., and ZWEIFEL, J. Considérations sur la longévité des graines de blé. [Considerations on the longevity of wheat seed.] Rev. Romande. d'Agr., de Vitic. et d'Arbor. 6: 41-42. 1950.

The paper refutes the idea of germinability of "mummy" wheats. Sixteen years of longevity is given for wheat stored in France.

96. ONLIEFF, A. [Method of preserving acorns for sowing.] Lesnoy Zhur. 45: [255]-259. 1915. [In Russian.]

Article describes solely a method of burying acorns underground for overwintering. (From Preserving Acorns for Growing by R. Z.: Forestry Quart. 13: 554-555. 1915.)

97. PALMÉR, J., and BORG, A. Lagringsförsök med betat utsäde. [Storage trials with treated seed.] Svensk Frötidn. 24: 2-4. 1955. [In Swedish.]

Small amounts of wheat, oats, and barley, with moisture content from 14.4 to 18.6 percent, were unaffected by treatment with Panogen and a subsequent storage of 5 to 7 months.

98. PIDOTTI, O. A. [Influence of length of storage upon germination of herbaceous perennial seeds.] Akad. Nauk SSSR Bot. Inst. Trudy, Ser. 6, Introd. Rast. i Zel. Stroit., 2: 361-367. 1952. [In Russian.]

The decline in viability of seeds of 32 species stored under ordinary room conditions was studied over an 8-year period. Some of the longest lived were *Astragalus cicer*, *Bellis perennis*, *Hedysarum alpinum*, and *Lupinus polyphyllus*. Among those with a longevity of only 3 years were *Cephalaria gigantea*, *Digitalis ambigua*, *D. ciliata*, *Gentiana* spp., and *Rhodiola* (*Sedum*) *kirilowii*.

99. RANCKEN, M. Der Einfluss von Feuchtigkeit und Temperatur auf die horten Kleesamen während der Aufbewahrungszeit. [The influence of moisture and temperature on hard clover seed during time of storage.] Internatl. Seed Testing Assoc. Proc. 9: [263]-271. 1937.

Concerns the softening of hard clover seed stored for 4 months under a bell jar, on the soil surface, and in a laboratory. Storage under the bell jar and germination on soil were more effective in softening seeds than laboratory storage.

100. RICHTER, O. Lagerung feuchten Getreides. [Storage of moist grains.] Mitt. f. die Landw. 57: 824. 1942.

Report is a popular-type article of one column, suggesting the mixing of damp grain with dry, chopped straw and the providing of air circulation during storage.

101. RODIONENKO, G. I. [The iris seed and its characteristics.] Akad. Nauk SSSR Dok. 104: 653-656. 1955. [In Russian.]

Some species of iris seeds remained viable after storage for 5 to 6 years. (From Hort. Abs. v. 26, No. 3007. 1956.)

102. ROHMEDER, E. Die Vermehrung der Papplen durch Samen. [The reproduction of poplars by seed.] Forstarchiv 17: [73]-80. 1941.

Cotton-free seeds retained their viability for several months when stored at 2° to 4° C. In partial vacuum the seeds remained viable up to a year, but preservation by means of low temperatures appeared more effective. (From Biol. Abs. v. 15, No. 22611. 1945.)

103. RYABININ, V. P. [For a high quality of stored forest seeds.] Lesnoe Khoz. 5 (8): 50-51. 1952. [In Russian.]

Discusses only the screening and processing of seed prior to storage. It is largely a "pep talk" on methods of attaining or exceeding quotas.

104. SAKALO, V. D. [Effect of storing conditions on planting quality of maize seeds.] Dostizh. Nauk. i Peredov. Opyta v Selsk. Khoz. 1953. (8): 74-77. 1953. [In Russian.]

This storage experiment had a duration of only 4 months. Maize with an initial moisture content of 29.2 percent was stored in a heated room and had a final germination of 90.0 percent. When the seed was dried to 13.5 percent moisture and stored in a cold room, it had a final germination of 99 percent. When not previously dried, the maize lost viability rapidly when it was stored in a cold room.

105. SAMPIETRO, G. Per prolungare la longevità nei semi di riso. [Prolonging the longevity of rice seed.] Gior. di Risic. 21: 1-5. 1931. [In Italian.]

Rice dried to 5 percent moisture and stored in nitrogen had 99 percent germination after 8 years, but with 13 percent moisture all viability was lost. Seeds with either 5 percent or 13 percent moisture lost all viability when stored with CO_2 in air or in a vacuum. (From Chem. Abs. 25: 2172. 1931.)

106. SCARASCIA, G. T. Effetti morfologici e mutativi dell'invecchiamento del seme in Nicotiana tabacum L. [Morphological and mutational effects of aging on seed of Nicotiana tabacum L.] Tabacco [Rome] 61: 270-290. 1957. [English summary, p. 289.]

When seeds of four varieties of tobacco were stored, decreases in viability and increases in chromosome mutations were only slight up to 3 years but became more marked as the storage period was extended to 4 to 5 years. (From Hort. Abs. v. 28, No. 2726. 1958.)

107. SCARASCIA, G. T., SCARASCIA-VENEZIAN, M. E., and GIOVANNOZZI-SERMANNI, G. Sull'invecchiamento del seme di Nicotiana. Osservazioni citologiche e biochimiche. [The aging of Nicotiana seed. Cytological and biochemical observations.] Tabacco [Rome] 60: 278-285. 1956. [English summary, p. 284.]

Germinability of tobacco seed fell steadily for 4 years and dropped sharply in the fifth year. Abnormal chromosome behavior increased with declining viability of seeds. (From Hort. Abs. v. 27, No. 597. 1957.)

108. SCHJELDERUP-EBBE, T. Über die Lebensfähigkeit alter Samen. [On the vitality of aged seeds.] Norske Vidensk. Akad. i Oslo, Mat. Nat. Kl. Skr. 1935, No. 13, 178 pp. 1936.

Seeds of 1,254 species ranging in age from 34 to 112 years were tested in Sweden. Sphaeralcea abutiloides, 74 years old with 43 percent germination, was the oldest viable species. The largest proportion of viable seeds were legumes.

109. SCHLOESING, A.-T., and LEROUX, D. Essai de conservation de graines en l'absence d'humidité, d'air et de lumière. [Studies on the conservation of seeds in the absence of moisture, air, and light.] Acad. d'Agr. de France Compt. Rend. 29: 204-206. 1943.

Tobacco seed with an initial germination of 90 percent was sealed with quicklime in evacuated glass tubes. After storage for 20 years 9 months, the seed had a germination of 87 to 92 percent.

110. SCHMIDT, H.-H. Die Keimung überlagerter Erbsensorten. [The germination of carried-over pea varieties.] Saatgut-Wirtsch. 5: 279-283. 1953.

Several varieties of pea harvested in 1948 and 1949 were imported to Germany and tested for germination in 1953. Many abnormal primary roots developed with a subsequent development of many adventitious roots.

111. SCHULTZE, J. H. Silochäcte in Getreidespeichern. [Storing grain in silos.] Wochenschr. f. Brau. 21: 410-411. 1904.

Paper is of a general nature regarding the construction of silos for grain storage. A limit given for safe storage was 12 percent moisture.

112. SCHWEMMLE, J. Keimversuche mit alten Samen. [Germination studies with old seeds.] Ztschr. f. Bot. 36: [225]-261. 1940.

The older the seeds of Oenothera berteriana, the poorer and slower was their germination. Material was obtained from aged seed that had an inhibiting effect on the germination of fresh seed. This effect was more pronounced with complex heterozygotes.

113. SENGBUSCH, R. von. Die Erhaltung der Keimfähigkeit von Samen bei tiefen Temperaturen. [Maintenance of viability of seed at low temperatures.] Züchter 25: 168-169. 1955.

Hemp and rye seeds stored at -20° C. retained 90 and 98 percent viability, respectively, for 3 years, but viability was lost when they were stored at 20°. Either temperature was satisfactory for sugar beet seed over a 5-year period. The embryos of hemp and rye were not injured by a temperature as low as -40°. (From Field Crop Abs. v. 8, No. 1474. 1955.)

114. SHKVARNIKOV, P. K. [The influence of temperature and moisture on the mutations in resting seeds.] Semenovodstvo* 1935 (1): 46-52. 1935. [In Russian.]

In three plants of Crepis tectorum mutated cells were produced by 100 percent of the seeds that had received a treatment of 40° C. for 30 days. Mutation rates were observed to be lower following a treatment of 95° for 25 minutes than for other treatments with lower temperatures of shorter durations.

115. SHKVARNIKOV, P. K. [The increase of the mutation rate in wheat as a result of prolonged storage of the seed.] Biol. Zhur. [Moscow] 5: 513-520. 1936. [In Russian. German summary, p. 520.]

In the F_1 populations from the seed of 2 varieties of Triticum vulgare (= T. aestivum) stored 6 to 10 years, one variety had 288 mutants out of 26,874 plants and the other had 192 out of 29,531. Almost all of the parental mutants were chimeras, and the transmission of these to their progeny appeared partially proportional to the length of storage. One control of untreated seed had a mutation rate of 0.109 percent as compared with 0.6 to 2.4 percent for treated seed. (From Plant Breeding Abs. v. 7, No. 163. 1936.)

116. SHKVARNIKOV [SCHKWARNIKOW], P. K. Einfluss hoher Temperature auf die Mutationsrate bei Weizen. [The influence of high temperature on the mutation rate in wheat.] Planta 25: [471]-480. 1936.

Winter wheat was subjected to temperatures ranging from 30° to 60° C. for periods of 6 to 31 days. Only slight differences in germination resulted between 30° and 40° treatments, but 60° temperatures had a detrimental effect even with the 6-day period. In the seedlings from the treated seed, abnormalities ranged from 8 to 20 percent; in the F_1 population the inherited mutations ranged from 2.4 to 8.6 percent. Although not in direct proportion, longer exposure rates resulted in a larger number of mutations. Seeds stored under room conditions produced 0.05 to 0.1 percent abnormal plants.

117. SHKVARNIKOV [SCHKWARNIKOW], P. K. Wirkung hoher Temperature auf die Mutationsrate von Crepis bei verschiedener relativer Luftfeuchtigkeit. [The effect of high temperature on the mutation rate in Crepis at different relative humidities.] Planta 25: [689]-695. 1936.

With seed of Crepis capillaris subjected to a temperature of 45° C. and relative humidities from 20 to 80 percent in a storage of 5 to 20 days, the number of mutations increased to a maximum of 42.1 percent as the treatment at 60 percent relative humidity was increasing to 20 days.

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*Later in 1935 becoming Selektsiya i Semenovodstvo.

118. SHKVARNIKOV [SCHKWARNIKOW], P. K. Über Erhöhung der Mutationsrate bei Weizen nach langer Aufbewahrung der Samen. [On the increase of the mutation rate in wheat after long storage of the seed.] Genetica 19: 188-199. 1937.

Wheat seed stored 7 to 8 years before planting resulted in plants with a mutation rate between 6.2 and 37.9 percent. Older seed gave a higher mutation rate than young seed, but the rate was not proportional to the age. A mutation rate of 0.6 to 2.4 percent was observed in the progeny of plants produced from stored seed as compared with one of 0.109 percent for progeny of plants from fresh seed.

119. SHKVARNIKOV, P. K. [Mutations in seeds and their significance for a seed culture and selection of plants.] Acad. des Sci. de l'URSS, Ser. Biol., Bul. 1939 (6): [1009]-1054. 1939. [In Russian. English summary, p. 1054.]

Paper is a review and report on causes of mutations in aging seeds. Mutations appeared to increase more rapidly as age advanced and are considered to be initiated by chemical changes in the seeds. (From English summary.)

120. SHKVARNIKOV [SCHKWARNIKOW], P. K., and NAVASHIN [NAWASCHIN], M. S. Über die Beschleunigung des Mutationsvorganges in ruhenden Samen unter dem Einfluss von Temperaturerhöhung. [On the acceleration of the rate of mutations in resting seed under the influence of increased temperatures.] Planta 22:[720]-736. 1934.

Seed of Crepis tectorum heated to 54° to 55° C. for periods of 20 to 44 days showed an increase in the number of mutations (principally translocations) as the duration of heating time was increased. The similarity of heat effects to X-ray effects is shown. Possible mutation effects from drying of seed by heat are pointed out.

121. SHMAL'KO, V. S. [Storage of seeds of naked oats.] Selek. i Semen. 1952 (5): 72-73. 1952. [In Russian.]

A storage depth for naked oats not exceeding 0.5 meter is recommended, also aeration 5 times as often as for covered oats. (From Herb. Abs. v. 5, No. 1086. 1935.)

122. SMEDT, A. de. La récolte et la conservation de semences d'essences forestières. [The harvesting and preservation of seeds of forest species.] Annu. Agr. et Hort. [Gand, Belgique] (1950-51) 3: 100-103. 1950.

This article covers no experimental work but gives recommended methods for the preservation of seeds of oak, beech, chestnut, and some conifers.

123. SOLOV'EVA, M. A. [Fruit seed storage.] Sad i Ogorod 1950 (10): 24-28. 1950. [In Russian.]

Seeds of apple, pear, apricot, cherry-plum, and sour cherry were preserved best at a relative humidity of 50 to 55 percent. Percentage of germination decreased as relative humidity increased. (From Hort. Abs. v. 21, No. 1356. 1951.)

124. SOLOV'EVA, M. A. [The conditions for prolonged storage of fruit seeds.] Agrobiologiya 1953 (1):[81]-93. 1953. [In Russian.]

Depending on variety, the moisture equilibria of apple seed ranged from 9.31 to 10.50 percent at 50 to 55 percent relative humidity, and from 12.37 to 15.65 percent at 80 to 90 percent relative humidity. For the same respective humidities the equilibria for pear seed ranged from 10.49 to 11.68 percent, and from 13.86 to 16.25 percent. Apricot seed had 9.95 percent moisture at 50 to 55 percent relative humidity, and 14.64 percent at 80 to 90 percent. The best preservation over a period of 935 days for seeds of apple, pear, plum, and apricot was over $CaCl_2$ at 2° to 10° C. Under laboratory conditions of 20° to 25° and 50 to 65 percent relative humidity, keeping qualities of apple, plum, and apricot were approximately the same when the storage was in flasks or sacks. Flasks were superior when these seeds were kept in a storeroom at 2° to 10° in 80 to 90 percent relative humidity.

125. SOLOV'EVA, M. A., and KOTSYUBINSKAYA, V. N. [Effect of storage conditions of seed on germination and yield of standard root stocks.] Sad i Ogorod 1955 (9): 53-55. 1955. [In Russian.]

Seeds of apple and pear with 10 to 11 percent moisture were stored at 2° to 10° C. without loss of germination or vigor for 2 years when sealed with $CaCl_2$. (From Hort. Abs. v. 26, No. 149. 1956.)

126. SPRENGER, J. J. I. Verslag van bewaarproeven met zaaizaad in twee pakhuizen uitgevoerd tijdens het winterseizoen 1952-53. [Report on storage tests with seed in two grain stores during the winter 1952-53.] [Wageningen] Cent. Inst. v. Landbouwk. Onderzoek., Droogtechn. Lab., Pub. 45, 7 pp. [1954.]

Overwinter storage studies with particular reference to moisture equilibria of oats and flax showed that flax stored at 74 percent relative humidity had a moisture content of 12.5 percent at 6° C. and a content of 10 percent at 15°. No such difference was observed in the case of oats. (From Field Crops Abs. v. 8, No. 1015. 1955.)

127. SPRENGER, J. J. I. Verslag van bewaarproeven met zaaizaad uitgevoerd tijdens het winterseizoen 1953-54. [Report on storage trials with seed, carried out in the winter of 1953-54.] [Wageningen] Cent. Inst. v. Landbouwk. Onderzoek., Droogtechn. Lab., Pub. 62, 8 pp. [1955.]

A drop of only 2 to 4 percent in germination of barley with 16.4 to 16.9 percent moisture was noted during a storage period from November to February. For safe storage of rye, oats, maize, lupine, pea, grass, beet, linseed, and kale, a reduction in moisture is recommended from 0.5 to 10.0 percentage points below the usual amount encountered under uncontrolled laboratory conditions. (From Field Crop Abs. 10, No. 909. 1957.)

128. STAHL, C. Forsøg med Opbevaring af Rødkløverfrø. [Experiments on the storage of red clover.] Nord. Jordbrugsforsk. 12: [313]-326. 1930. [In Danish.]

Periodical germination tests of red clover seed samples stored under different conditions showed that the seed maintained germination capacity better when it was stored in a dry, heated laboratory than when it was stored commercially by seedsmen. In the laboratory the average germination, including that for hard seeds, was reduced in 2 years from 95 to 74 percent. In commercial samples the average germination during the same time was reduced to 44 percent. The results emphasize the importance of dry storage. (From Biol. Abs. v. 6, No. 7957. 1932.)

129. STUBBE, H. Samenalter und Genmutabilität bei Antirrhinum majus L. (Nebst einigen Beobachtungen über den Zeitpunkt des Mutierens während der Entwicklung.) [Old seed and gene mutations in Antirrhinum majus L. (Including a few observations on the initiation of mutations during development.)] Biol. Zentbl. 55: 209-215. 1935.

Usually 1 percent of the plants from fresh seeds of Antirrhinum majus were found to have mutations as compared with 5 percent from seeds 7 to 9 years old and 14 percent from seeds 10 years old.

130. STUBBE, H. Weitere Untersuchungen über Samenalter und Genmutabilität bei *Antirrhinum majus*. [Further investigations on aging seeds and gene mutability in *Antirrhinum majus*.] Ztschr. f. Indukt. Abstam. u. Vererbungsl. 70: 533-537. 1935.

In this article reference is made to the author's previous work on the influence of age on mutations produced in stored seed of *Antirrhinum*. A linear relationship between age and mutation rate could not be established. This led to the conclusion that factors other than age also have an influence on the frequency of mutations in stored seeds.

131. STÜTZ, H. Über den Einfluss verschiedenartiger Lagerung auf die Hartschaligkeit von Kleesamen. [The effect of various kinds of storage upon hardness of coat in legume seeds.] 42 pp. 1933. [Doctor's dissertation, Hamburg Univ.]

Storage of seeds of alfalfa and red, white, and alsike clovers at cold temperatures and high relative humidities resulted in a lower percentage of the seed being hard than did storage at approximately 18° C. The percentage of hard seeds gradually dropped, under both warm and cool conditions, for seed in storage longer than 6 months. (From Herb. Abs. 3: 238. 1933.)

132. TAKAGI, I. [On the storage of mulberry seeds.] Tokyo Imp. Seric. Col. Res. Bul. 2: 1-22. 1939. [In Japanese. English summary, Jap. Jour. Bot. 10: (66). 1940.]

Mulberry seeds were kept highly viable for 14 years over $CaCl_2$ plus 20-percent H_2O, or over 43.8-percent H_2SO_4. The controls were viable for only 4 months. Moisture of seeds over the reagents was 4.1 to 4.2 percent, a content concluded to be in equilibrium with 48 percent relative humidity, since such a humidity was found in the desiccator with H_2SO_4. (From Hort. Abs. v. 10, No. 1311. 1940.)

133. THOMAS, B. Über die Bedeutung des Feuchtigkeitsgehaltes für die Lagerung des Getreides. [The importance of moisture content in the storage of grain.] Ztschr. f. das Gesam. Getreidew. 28: 66-69. 1941. (Also in Wochenschr. f. Brau. 58: 157-158. 1941.)

Wheat with moisture contents of 12 and 14 percent was satisfactorily stored at 10° and 20° C. for 36 weeks, but at 30° 12 percent moisture was the upper limit of safety. For the same period of storage, rye tolerated a moisture content of 14 percent when stored at 20°.

134. TIRÉN, L. Förvaring av skogsfrö. Erfarenhetor från Hällnäs och Bollnäs. [Storing of seed of forest trees. Experiences at Hallnas and Bollnas.] Skogen 29: 350-352. 1942. [In Swedish.]

Sealed containers are recommended for the storage of tree seeds, with temperatures no higher than 5° to 6° C. The data show a possible seed longevity of 13 to 15 years. (From Forestry Abs. 5: 177. 1944.)

135. ULLMANN, W. Über die Keimfähigkeitsdauer (Lebensdauer) von landwirtschaftlichen und gartenbaulichen Samen. [On the duration of germinability (life duration) of agricultural and horticultural seeds.] Saatgut-Wirtsch. 1: 174-175, 195-196. 1949.

A tabulation of the approximate longevity of seeds of several hundred agricultural, medicinal, spice, and ornamental plants stored under satisfactory conditions.

136. ULTÉE, A. J. Het bewaren van zaadkoffie. [Storage of coffee seed.] Arch. v. Koffiecult. Nederland Indië 7: [75]-83. 1933. [In Dutch.]

In the Dutch East Indies, coffee seed was found to have 95 percent germination after 6 months of storage in charcoal moistened with 150 gm. of water to 1 kg. charcoal. Germination was 78 percent after 9 months. (From Biol. Abs. v. 10, No. 4111. 1936.)

137. VIANNA e SILVA, M. A influência da idade da semente na germinação do arroz. [The influence of age of seed on the germination of rice.] [18] pp. (Published by Min. da Econ., Comissão Regulad. do Com. de Arroz.) 1947. [In Portugese.]

Rice varieties from four consecutive crop years were stored under room conditions in Portugal. Original germinations of the varieties were not given, but the results showed that seed of all varieties could be carried over without a great loss in viability for 2 years, that seed of some of the varieties could be carried over 3 years.

138. VILMORIN, R. de. Note sur la conservation de la faculté germinative des graines d'Abies pectinata. [Note on the conserving of the germinability of seeds of Abies pectinata.] Acad. d'Agr. de France Compt. Rend. 30: 509-512. 1944.

Seed of Abies pectinata (= A. alba) was preserved with high germination for 1 year at -18° C. regardless of whether they were previously dried or not, or whether they were stored in air, under vacuum, or with nitrogen.

139. VINCENT, G. Uskladňování smrkových semen. [Storage of spruce seed.] Českoslov. Akad. Zeměděl. Sborn. 12: 469-474. 1937. [In Czechoslovakian. German summary, pp. 472-474.]

Seed of spruce retained its viability best in a jute sack stored in an attic. Storage in the cone was superior to dry, dewinged seed. Seed stored in a basement lost viability. (From Biol. Abs. v. 12, No. 5408. 1938.)

140. VINCENT, G. Uskladňování modřínových semen. [Storage of larch seed.] Českoslov. Akad. Zeměděl. Sborn. 12: 557-560. 1937. [In Czechoslovakian. German summary, pp. 559-560.]

Larch seed was 54.5 percent viable after 3 years of storage in an attic, but seed stored in a basement lost all viability. Seed stored in the cone was better than extracted seed. (From Biol. Abs. v. 12, No. 5409. 1938.)

141. VINCENT, G. Die Aufbewahrung der Fichten- und Lärchensamen. [The storage of spruce and larch seeds.] Ztschr. f. Forst u. Jagdw. 70: 45-51. 1938.

Spruce and larch seeds, in the cones, were stored satisfactorily for 5 years in a cool, well-ventilated area. Dewinged seeds kept as well as winged ones. The results showed that larch seeds should not be kept longer than 3 years, nor spruce more than 5 years. (From Biol. Abs. v. 12, No. 3605. 1938.)

142. WALTHER, R. Über die Verlängerung der Keimfähigkeit von Saatgut. [On the prolonging of the germinability of seeds.] Saatgut-Wirtsch. 5: 225-226. 1953.

A popular-type review of Jensen's work on the use of light in the preservation of seeds. (See reference number 46.)

143. WOLLENWEBER, H. W. Über die Lebensdauer von Kartoffelsamen. [On the longevity of potato seed.] Angew. Bot. 24: [259]-260. 1942.

Potato seed enclosed in stoppered bottles and stored at room temperature was wholly viable after 13 years. After 18 years germination dropped to 26 percent, in 20 years to 17 percent.

144. WYTTENBACH, E. Der Einfluss verschiedener Lagerungsfaktoren auf die Haltbarkeit von Feldsämereien (Luzerne, Rotklee und Gemeinem Schotenklee) bei länger dauernder Aufbewahrung. [The influence of various storage factors on the keeping quality of agricultural seeds (lucerne, red clover, and birdsfoot trefoil) during long periods of storage.] Landw. Jahrb. der Schweiz 69: [161]-196. 1955. [French résumé, pp. 188-190.]

Seeds of alfalfa, red clover, and birdsfoot trefoil, with 11 percent moisture, were preserved satisfactorily for 2 years at 5^{o} to 10^{o} C. and with relative humidity 60 percent or less. Light, darkness, and the presence or absence of CO_2 had no effect on longevity. Loss of germination was accompanied by a marked increase of lactic acid, sometimes 50 percent over normal. (From Herb. Abs. v. 25, No. 803. 1955.)

145. WYTTENBACH, E., and FREY, E. Versuche über die Erhaltung der Keimfähigkeit von Kleesaatgut bei länger dauernder Lagerung. [Experiments on the maintenance of germinating capacity in leguminous seed under long-duration storage.] Mitt. f. die Schweiz. Landw. [Zurich] 2: 9-15. 1954.

Moisture above 11 percent was critical for storage of alfalfa, red clover, and trefoil. Loss of viability occurred in 9 to 12 months of storage at room temperatures when the moisture content exceeded 12 to 15 percent. Humidities above 70 percent were harmful. (From Herb. Abs. v. 24, No. 473. 1954.)

146. YAKUSHEVA, E. I. [Duration of viability of seeds of some herbage legumes.] Selek. i Semen. 1947 (1): [41]-45. 1947. [In Russian.]

When stored in metal boxes, seeds of blue lucerne (*Medicago sativa*) were preserved for 8 years; in 15 years, germination dropped 25 percent; in 16 to 19 years, germination dropped 50 percent. *M. falcata* was held for 23 years with a drop of only 15 percent in viability. *Onobrychis sativa* (= *O. viciaefolia*) lost all viability in 12 years. Spring vetch remained viable for 8 years, followed by a sharp decline in viability after 11 years, and an almost complete loss in 20 years. Seeds of winter vetch also declined sharply in viability after 11 years. Seeds of *Melilotus* spp., *Lotus corniculatus*, and *Astragalus* spp. were long lived. (From Herb. Abs. v. 17, No. 1695. 1947.)

147. ZEDERBAUER, E. Versuche über Aufbewahrung von Waldsämereien. [Studies on the preservation of forest seed.] Centbl. f. das Gesam. Forstw. 36: 116-121. 1910.

This article covers overwinter storage of seeds of nine tree species under eight storage conditions. *Abies alba* and *Pinus peuce* were preserved under treatments approximating natural conditions (low temperatures and moisture contents in equilibrium with soil). *P. sylvestris* required high moisture in a cellar. *Picea excelsa* (= *P. abies*) was preserved best in air with moderate moisture. *Larix europaea* (= *L. decidua*) was maintained best in an unheated room with moderate moisture, *Fagus sylvatica* in an unheated room and mixed with sand, *Quercus cerris* and *Aesculus hippocastanum* buried outdoors.

148. ZERFOSS, G. E. Aufbewahren überliegender Samen. [Storage of overlying seed.] In Merkbl. Beratungsstelle f. Waldsamenbesch No. 3, pp. 9-10. (Suppl. of Schweiz. Ztschr. f. Forstw. v. 97.) 1946.

Directions are given for the construction and filling of an underground chamber for overwinter storing of seeds of ash, maple, hornbeam, and others. No storage experiments are involved.

149. ZINGSTRA, H. 10-jarige kiemproef met aardappelzaden. [A 10-year germination trial with potato seed.] Nederland. Alg. Keurings. Meded. 14: 115. 1958.

Potato seed with an original 90 percent germination was stored in packages in a wooden cabinet at room temperatures. The seed still germinated 90 percent after 6 years; at 10 years the percentage of viable seed had dropped to 27 percent with a germination energy of 0. Through the first 5 years the germination energy was higher than it was initially.

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